

Ravindra Pal Singh · Ramesh Kothari
Prakash G. Koringa
Satya Prakash Singh *Editors*

Understanding Host-Microbiome Interactions - An Omics Approach

Omics of Host-Microbiome Association

Understanding Host-Microbiome Interactions - An Omics Approach

Ravindra Pal Singh • Ramesh Kothari
Prakash G. Koringa • Satya Prakash Singh
Editors

Understanding Host-Microbiome Interactions - An Omics Approach

Omics of Host-Microbiome Association

 Springer

Editors

Ravindra Pal Singh
Saurashtra University
UGC-CAS Department of Biosciences
Saurashtra University
Rajkot, Gujarat
India

Ramesh Kothari
Saurashtra University
UGC-CAS Department of Biosciences
Saurashtra University
Rajkot, Gujarat
India

Prakash G. Koringa
Anand Agricultural University
College of Vet. Sc. and Animal Husbandry
Anand Agricultural University
Anand, Gujarat
India

Satya Prakash Singh
Saurashtra University
UGC-CAS Department of Biosciences
Saurashtra University
Rajkot, Gujarat
India

ISBN 978-981-10-5049-7

ISBN 978-981-10-5050-3 (eBook)

DOI 10.1007/978-981-10-5050-3

Library of Congress Control Number: 2017952944

© Springer Nature Singapore Pte Ltd. 2017

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, express or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Printed on acid-free paper

This Springer imprint is published by Springer Nature

The registered company is Springer Nature Singapore Pte Ltd.

The registered company address is: 152 Beach Road, #21-01/04 Gateway East, Singapore 189721, Singapore

Preface

Microbial communities and their hosts (human, plant, and animal) have been coevolved and coadapted under diverse environmental selective pressures over millions of years. These hosts rely on integrated interactions of specific microbiome for their successful survival. The evolution of the meta-omics (metagenomics, meta-transcriptomics, and meta-proteomics) technologies in sequencing is fostering a detonation of interest in how the gut and rhizospheric microbiomes impact physiology and propensity to disease. These advancements in technologies have recently been provided with deeper understanding of the complexity of the host-microbe association in terms of phylogeny and function connectivity. Among other host microbiomes, meta-omics technologies have significantly been carried out on human gut and plant rhizospheric microbiomes. Those studies have found that small fraction of the whole microbial communities are always associated with the host, and, assisting in host's physiology, such microbial communities sometimes are referred to as a core microbiome. The core microbial communities are now being used for modulating the host microbiome in order to reduce the incidence of diseases and improving the health of the hosts. However, much information of these interesting associations in different research articles is available from the Western world and has limited availability from Asian counties. In this book, thus, we have collected several chapters from prominent scientists from Asian counties which will be available to students at graduate and postgraduate levels.

Presently, a majority of scientists working on microbiology are trying to understand phylogeny and functional aspects of different host microbiomes. However, rapid development of these meta-omics technologies makes it hard to retrieve all the required informations from diverse research reports. The book, thus, will be an excellent resource to get updated information of different host microbiomes in terms of their community composition and interactive functions. As it demands tremendous and dedicated effort, we are extremely thankful to all the authors for their prompt responses and their contributions. I extend my earnest appreciation to Mr. Kumar of Springer for his valuable support to facilitate completion of the task.

Rajkot, India
Rajkot, India
Anand, India
Rajkot, India

Ravindra Pal Singh
Ramesh Kothari
Prakash G. Koringa
Satya Prakash Singh

Contents

Part I Next Generation Sequence Technology

- 1 The Omics Era and Host Microbiomes 3**
Ravindra Pal Singh and Ramesh Kothari
- 2 Uncultivated Lineages and Host–Microbe Interaction
in Saline Environment 13**
Kruti G. Dangar, Nirali M. Raiyani, Rupal D. Pandya,
and Satya P. Singh
- 3 Exploring Metagenomes Using Next-Generation Sequencing 29**
Jalpa R. Thakkar, Pritesh H. Sabara, and Prakash G. Koringa
- 4 Metagenomics: An Era of Throughput Gene Mining 41**
Bhupendra Singh Panwar and Ruchi Trivedi
- 5 Prospects and Progress in Extreme Biosphere Microbiome 55**
Pravin Dudhagara, Ramesh Kothari, Anjana Ghelani, Jalpa Rank,
and Rajesh Patel

Part II Human Microbiome

- 6 16S rRNA Metagenomics of Asian Gut Microbiota 71**
Juma Kisuse and Jiro Nakayama
- 7 Human Milk Microbiome: A Perspective to Healthy
and Infected Individuals. 83**
Chaitanya Joshi and Anju Kunjadiya
- 8 Role of Gut Microbiome in Neuromodulation 105**
Suganya Kannan, Govindan Krishnamoorthy, Prabha Palanichamy,
and Murugan Marudhamuthu

Part III Plant Microbiome

9 Metagenome of Rhizosphere and Endophytic Ecosystem.	125
P.U. Krishnaraj and Malik Ahmed Pasha	
10 Unravelling the Interaction of Plant and Their Phyllosphere Microbiome	157
Chetana Roat and Meenu Saraf	
11 A Metagenomic Approach to Identify Distinct Rhizospheric and Endophytic Bacterial Communities from Roots and Root Nodules of <i>Vigna radiata</i>	173
Bhagya Iyer and Shalini Rajkumar	
12 Metagenomics of Plant Rhizosphere Microbiome	193
Ravindra Soni, Vinay Kumar, Deep Chandra Suyal, Lata Jain, and Reeta Goel	
13 Plant–Pathogen Interactions: A Proteomic Approach.	207
Amanpreet Kaur, Anil Kumar, and M. Sudhakara Reddy	
14 Biochemical and Proteomics Analysis of the Plant Growth-Promoting Rhizobacteria in Stress Conditions	227
Kalpna D. Rakholiya, Mital J. Kaneria, Satya P. Singh, V. D. Vora, and G.S. Sutaria	
15 Endophytic Actinobacteria and Their Interactions with Plant Host Systems	247
Sangeeta D. Gohel, Amit K. Sharma, Foram J. Thakrar, and Satya P. Singh	
16 Metatranscriptomic Studies of the Plant Rhizosphere for Finding Biological Agents.	267
Vishal Kothari, Charmy Kothari, Jalpa Rank, Anjali Joshi, Ravindra Pal Singh, and Ramesh Kothari	

Part IV Animal Microbiome

17 Canine and Feline Microbiomes	279
Corrin V. Wallis, Zoe V. Marshall-Jones, Oliver Deusch, and Kevin R. Hughes	
18 Recent Advances in the Metagenomics of Marine Mammals Microbiome	327
Chandra Shekar Mootapally, Paresh Poriya, Neelam Mustakali Nathani, Balu Alagar Venmathi Maran, and Indra Ramjibhai Gadhvi	

19

**Advancements in Molecular Techniques and Bioinformatics
for Understanding the Rumen Microbiome**

337

Neelam M. Nathani, Amrutlal K. Patel, Chandra Shekar Mootapally,
Ramesh K. Kothari, and Chaitanya G. Joshi

Part V Marine Microbiome and Microbial Interaction

20

**Multi-omic Approaches for Mapping Interactions Among
Marine Microbiomes.**

353

Shubhrima Ghosh, Rameshwar Tiwari, R. Hemamalini, and S.K. Khare

Contributors

Kruti G. Dangar UGC-CAS Department of Biosciences, Saurashtra University, Rajkot, India

Oliver Deusch The WALTHAM Centre for Pet Nutrition, Leicestershire, UK

Pravin Dudhagara Department of Biosciences (UGC-SAP), Veer Narmad South Gujarat University, Surat, India

Indra Ramjibhai Gadhvi Department of Marine Science, Maharaja Krishnakumarsinhji Bhavnagar University, Bhavnagar, Gujarat, India

Anjana Ghelani Department of Life Sciences, Hemchandracharya North Gujarat University, Patan, India

Shubhrima Ghosh Enzyme and Microbial Biochemistry Laboratory, Department of Chemistry, Indian Institute of Technology Delhi, Hauz Khas, New Delhi, India

Reeta Goel Department of Microbiology, CBSH, G.B.Pant University of Agriculture and Technology, Pantnagar, Uttaranchal, India

Sangeeta D. Gohel Department of Biosciences (UGC-CAS), Saurashtra University, Rajkot, Gujarat, India

R. Hemamalini Enzyme and Microbial Biochemistry Laboratory, Department of Chemistry, Indian Institute of Technology Delhi, Hauz Khas, New Delhi, India

Kevin R. Hughes The WALTHAM Centre for Pet Nutrition, Leicestershire, UK

Bhagya Iyer Institute of Science, Nirma University, Ahmedabad, Gujarat, India

Lata Jain ICAR-National Institute of Biotic Stress Management, Baronda, Chhattisgarh, India

Anjali Joshi Department of Biosciences (UGC-CAS), Saurashtra University, Rajkot, Gujarat, India

Chaitanya G. Joshi Department of Animal Biotechnology, College of Veterinary Science & Animal Husbandry, Anand Agricultural University, Anand, Gujarat, India

Mital J. Kaneria Department of Biosciences (UGC-CAS), Saurashtra University, Rajkot, Gujarat, India

Suganya Kannan Department of Microbial Technology, School of Biological Sciences, Madurai Kamaraj University, Madurai, Tamil Nadu, India

Amanpreet Kaur Department of Biotechnology, TIFAC-Centre of Relevance and Excellence in Agro and Industrial Biotechnology (CORE), Thapar University, Patiala, India

S.K. Khare Enzyme and Microbial Biochemistry Laboratory, Department of Chemistry, Indian Institute of Technology Delhi, Hauz Khas, New Delhi, India

Juma Kisuse Department of Bioscience and Biotechnology, Faculty of Agriculture, Kyushu University, Fukuoka, Japan

Prakash G. Koringa Department of Animal Biotechnology, College of Veterinary Science and Animal Husbandry, Anand Agricultural University, Anand, Gujarat, India

Vishal Kothari Department of Biotechnology, Junagadh Agricultural University, Junagadh, Gujarat, India

Charmy Kothari Department of Biotechnology, Christ College, Rajkot, Gujarat, India

Ramesh K. Kothari UGC-CAS Department of Biosciences, Saurashtra university, Rajkot, Gujarat, India

Govindan Krishnamoorthy Department of Microbial Technology, School of Biological Sciences, Madurai Kamaraj University, Madurai, Tamil Nadu, India

P U Krishnaraj Department of Agricultural Microbiology, College of Agriculture, Vijayapura University of Agricultural Sciences, Dharwad, Karnataka, India

Vinay Kumar ICAR-National Institute of Biotic Stress Management, Baronda, Chhattisgarh, India

Anil Kumar Department of Biotechnology, TIFAC-Centre of Relevance and Excellence in Agro and Industrial Biotechnology (CORE), Thapar University, Patiala, India

Anju Kunjadiya Center for Interdisciplinary Studies in Science and Technology (CISST), Sardar Patel University, Anand, Gujarat, India

Balu Alagar Venmathi Maran Fisheries Science Institute, Chonnam National University, Yeosu, Republic of Korea

Zoe V. Marshall-Jones The WALTHAM Centre for Pet Nutrition, Leicestershire, UK

Murugan Marudhamuthu Department of Microbial Technology, School of Biological Sciences, Madurai Kamaraj University, Madurai, Tamil Nadu, India

Chandra Shekar Mootapally Department of Marine Science, Maharaja Krishnakumarsinhji Bhavnagar University, Bhavnagar, Gujarat, India

Department of Animal Biotechnology, College of Veterinary Science & Animal Husbandry, Anand Agricultural University, Anand, Gujarat, India

Jiro Nakayama Department of Bioscience and Biotechnology, Faculty of Agriculture, Kyushu University, Fukuoka, Japan

Neelam Mustakali Nathani Department of Life Sciences, Maharaja Krishnakumarsinhji Bhavnagar University, Bhavnagar, Gujarat, India

UGC-CAS Department of Biosciences, Saurashtra university, Rajkot, Gujarat, India

Prabha Palanichamy Department of Microbial Technology, School of Biological Sciences, Madurai Kamaraj University, Madurai, Tamil Nadu, India

Rupal D. Pandya UGC-CAS Department of Biosciences, Saurashtra University, Rajkot, India

Bhupendra Singh Panwar Department of Animal Biotechnology, College of Veterinary Science and Animal Husbandry, Anand Agricultural University, Anand, Gujarat, India

Malik Ahmed Pasha Department of Agricultural Microbiology, College of Agriculture, Vijayapura University of Agricultural Sciences, Dharwad, Karnataka, India

Amrutlal K. Patel Hester Biosciences Limited, Ahmedabad, Gujarat, India

Rajesh Patel Department of Life Sciences, Hemchandracharya North Gujarat University, Patan, India

Paresh Poriya Department of Marine Science, Maharaja Krishnakumarsinhji Bhavnagar University, Bhavnagar, Gujarat, India

Nirali M. Raiyani UGC-CAS Department of Biosciences, Saurashtra University, Rajkot, India

Shalini Rajkumar Institute of Science, Nirma University, Ahmedabad, Gujarat, India

Kalpna D. Rakholiya Department of Biosciences, Institute of Biotechnology, Saurashtra University, Rajkot, Gujarat, India

Jalpa Rank Department of Biosciences (UGC-CAS), Saurashtra University, Rajkot, Gujarat, India

Chetana Roat Department of Microbiology and Biotechnology, University School of Sciences, Gujarat University, Ahmedabad, India

Pritesh H. Sabara Department of Animal Biotechnology, College of Veterinary Science and Animal Husbandry, Anand Agricultural University, Anand, Gujarat, India

Meenu Saraf Department of Microbiology and Biotechnology, University School of Sciences, Gujarat University, Ahmedabad, India

Amit K. Sharma Department of Biosciences (UGC-CAS), Saurashtra University, Rajkot, Gujarat, India

Satya P. Singh Department of Biosciences (UGC-CAS), Saurashtra University, Rajkot, Gujarat, India

Ravindra Pal Singh Department of Biosciences (UGC-CAS), Saurashtra University, Rajkot, Gujarat, India

Department of Biological Chemistry, John Innes Centre, Norwich, UK

Ravindra Soni Department of Agricultural Microbiology, College of Agriculture, Indira Gandhi Krishi Vishva Vidyalaya, Raipur, Chhattisgarh, India

M. Sudhakara Reddy Department of Biotechnology, TIFAC-Centre of Relevance and Excellence in Agro and Industrial Biotechnology (CORE), Thapar University, Patiala, India

G.S. Sutaria Main Dry Farming Research Station, Junagadh Agricultural University, Rajkot, Gujarat, India

Deep Chandra Suyal Department of Microbiology, CBSH, G.B.Pant University of Agriculture and Technology, Pantnagar, Uttaranchal, India

Jalpa R. Thakkar Department of Animal Biotechnology, College of Veterinary Science and Animal Husbandry, Anand Agricultural University, Anand, Gujarat, India

Foram J. Thakrar Department of Biosciences (UGC-CAS), Saurashtra University, Rajkot, Gujarat, India

Rameshwar Tiwari Enzyme and Microbial Biochemistry Laboratory, Department of Chemistry, Indian Institute of Technology Delhi, Hauz Khas, New Delhi, India

Ruchi Trivedi Department of Animal Biotechnology, College of Veterinary Science and Animal Husbandry, Anand Agricultural University, Anand, Gujarat, India

V.D. Vora Main Dry Farming Research Station, Junagadh Agricultural University, Rajkot, Gujarat, India

Corrin V. Wallis The WALTHAM Centre for Pet Nutrition, Leicestershire, UK

About the Editors



Ravindra Pal Singh is a research assistant at the Department of Biochemistry, John Innes Centre, Norwich, UK. He obtained his Ph.D. from CSIR-CSMCRI, India, in 2013. During his scientific career, he has received several prestigious scholarships, such as an outstanding postdoctoral fellowship provided by Tel Aviv University, Israel, in 2013, a JSPS postdoctoral fellowship in 2013, and a Dr. D. S. Kothari postdoctoral fellowship provided by the UGC, India, in 2016. He has published 28 articles in different scientific journals and received a patent while working in the field of microbial ecology and bacteriology. He can be contacted at ravindrapal.1441@gmail.com.



Ramesh Kothari is currently working as a professor at the Department of Biosciences, Saurashtra University, Rajkot, Gujarat, India. He received a Ph.D. in microbiology from the Saurashtra University, Rajkot, in 2003. Soon after, he joined Christ College Rajkot where he served as an assistant professor for 14 years. He completed his postdoctoral research at Rutgers University, Newark, USA. His research work focuses on bioremediation and metagenomics. He has more than 41 international peer-reviewed research publications to his credit.



Prakash G. Koringa has been an assistant professor at Anand Agricultural University (AAU), Gujarat, India, since 2004. He obtained his Ph.D. from the Department of Animal Biotechnology, College of Veterinary Sciences and Animal Husbandry, AAU, Anand, Gujarat. His work focuses on rumen metagenomics and cecal microbiome in broilers and their application for the host health. He has published several research papers in peer-reviewed journals as well as a number of book chapters.



Satya P. Singh is currently working as professor and head at the UGC-CAS Department of Biosciences, Saurashtra University, Rajkot, Gujarat, India. He completed his master's in microbiology from the G. B. Pantnagar University of Agriculture and Technology, Pantnagar, India, and carried out his doctoral research at Griffith University, Brisbane, Australia. Prof. Singh has worked at the National Food Research Institute, Tsukuba, Japan, as a visiting scientist and also visited Yangon University, Myanmar, as visiting professor. Prof. Singh has been working on the diversity, phylogeny, and enzymatic characteristics of the halophilic/haloalkaliphilic bacteria, actinomycetes, and archaea of various saline ecosystems. He has published 82 research papers and contributed 17 book chapters in various books.

Part I

Next Generation Sequence Technology